Volume 3, Issue 3, 2025

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

COMPARATIVE EFFICACY OF TENSION BAND WIRE, DCP AND POP FOR THE TREATMENT OF OLECRANON AVULSION FRACTURE IN DOGS

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DOI: https://doi.org/10.5281/zenodo.15755794

Keywords
Ambulae; Fracture healing; Immovable; Malunion

Article History
Received on 23 April 2025
Accepted on 23 May 2025
Published on 31 May 2025

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Abstract

The treatment of avulsion fractures of the points of different bones which serve as the insertion of tendons, muscles and ligaments needs particular attention in order to enable these orthopedic patients to rehabilitate and ambulate normally. The main objective while treating these patients is to convert distracting forces of muscles into compressive forces. To achieve desired results, the procedures of tension band wire, compression plate and plaster of Paris applied on surgically avulsed Olecranon fracture, which gave us chance to ascertain the comparative efficacy of these techniques. A total number of 12 mongrel dogs divided into 3 groups Group A, Group B and Group C comprising 4 dogs each. In Group A the Olecranon of the dog surgically exposed and an avulsion transverse fracture is created by manual saw and fracture fragment is held in place by two Kirschner wires and Cerclage wire of 2mm in fashion of eight giving fracture site a proper strong compression. In Group B the surgically avulsed Olecranon fracture repaired using dynamic compression plate of 3.5mm 6 holes. In Group C Olecranon fracture created surgically but only external coaptation by POP done. All the dogs were kept in kennel cages for a period of sixteen weeks and evaluated on clinical and radiographic evidences. The analysis of the results indicates that tension band wire is a better choice for fixing the avulsed Olecranon with good callus formation and wound healing. Also studied comparison of Serum Calcium, Phosphorus and Alkaline phosphate values increased in first 10 days for all three groups but for Group A returned to normal on 60th day with the proper callus formation and for Group B it took more than 60 days. For Group C the ALP values have no significance as there was no callus formation. It indicates that serum Alkaline Phosphatase can be a good prognostic indicator in the fracture healing of Olecranon avulsion fracture in adult dogs. *Euthanasia was performed after the completion of*

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ISSN: (e) 3007-1607 (p) 3007-1593

experimental period.

INTRODUCTION

Elbow joint as a whole is a hinge joint, allowing the flexion and extension of the humerus over radius and ulna. During pronation and supination, the circumference of the radius is able to rotate itself in the radial notch of the ulna (Constantinescu and Constantinescu, 2009).

Fracture and dislocation of the elbow joint mostly present in many combinations. In case of open physis, fracture most likely to occur instead of the dislocation due to the inherent weakness of epiphyseal plate and epiphyseal softness. Types of the fractures are transcondylar, supracondylar, intercondylar fractures of the "T" or "Y" type, lateral condyle fracture, medial condyle fractures and fractures of the articular surfaces of the humerus. Adding to it, elbow fractures also included fractures of the ulna, proximal olecranon and proximal radius or radial head. Compound fractures of the elbow mostly have poor prognosis (Bingel, 1977). Young animals mostly face the transcondylar fracture of the elbow with open physis and are uncommon in clinical fracture. It differs with the supracondylar fracture in the sense it involves the joint capsule. Most of the animals with this type of fracture present with the fracture of physis also (Salter type I or II). We can use external fixation for undisplaced type of transcondylar fracture. In case of displaced transcondlylar fracture open reduction is mandatory with the small Kirschner wires use as cross pins for fixation. Activity restricted for 3 to 4 weeks with no splints (Mostosky, 1959).

Olecranon fractures are mostly reported in young animals and clinically presented along with apophyseal separation. When this picture seen in adult dogs it involves the joint also and the fracture is mostly comminuted type. Olecranon fractures well stabilized and the tension band wiring usually and dog comes to normal weight bearing within few days. There is a disagreement on the placement of wire that must take in relationship to the triceps tendon. There is some concern literature on the placement of wire that must cut through the tendinous portion of the tendon above the K wires for fixation. Wire would be placed cranial or caudal side of this tendon with good success rate. It is wise to use two K wires or Steinmann pins to stabilize the rotatory forces acting on it. Even in the cats must use two K wires. In case of comminuted fractures of olecranon and proximal ulna, an intrafragmentary screw along with the DCP should be used to stabilize the extra fracture fragment. Placement of the plate can be caudal to the extensor carpi ulnaris or flexor carpi ulnaris (Mason, 1978).

Fixation hardware failure remains a problem. Various materials and fixation techniques have been tested to provide an improved fixation of transverse olecranon and patellar fractures. The difference in biomechanically setup testing procedures makes it difficult to compare the best technique for the repair of olecranon avulsion fracture. However this study has been planned to see the comparative efficacy of the three different procedures for the repair of olecranon avulsion fracture in dogs, tension band wiring, DCP and conventional POP. To check the relative efficacy of tension band wiring and DCP plate and POP in the repair of olecranon fracture of the dogs. As we know the Avulsion fracture is a very unstable fracture so we need a proper surgical method for good stability of fracture fragment. Objectives of the present study are To check the comparative efficacy of tension band wiring , DCP and conventional POP techniques for the repair of olecranon Avulsion fracture in dogs and check the significance of serum alkaline phosphatase, serum calcium and serum phosphorus level in the healing process of olecranon avulsion fracture.

Materials and Methods

Ethical approval

The study was conducted at the Pet Center, Department of Clinical Medicine and Surgery of University of Veterinary & Animal Sciences, Lahore. It was approved by the Advanced Studies and Research Board of the University under the letter No: Dated:

Materials

Following are the materials used for the surgical procedures

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Pre-anesthesia and general anesthesia
Xylazine HCL-20% (Xylaz 20mg/ml by FARVET)
Atropine Sulphate (Atopin 1mg/1ml by SYMANS Pharmaceuticals Private Limited)
Ketamine HCL-5% (Ketarol 500mg/10ml by Global Pharmaceuticals Private Limited)

Analgesia
Buprenorphine 0.3mg/ml (Buepron by SUNIL Pharma (Private Limited)
Ketoprofen 10% (Selmore Pharmaceuticals)

Orthopedic instruments
Kirschnerwires 2mm
Orthopedic cerclage wire 2mm
Jacob's chuck/T-handle
Manual drill machine
Drill bit 2.7mm
Hammer
Dicalciumphosphate 3.5mm (4 and 6 holes)
Screw depth gauge
Screw driver 3.5mm
Wire plier
Wire cutter
Bone holding clamps (small)
Cortical screws of 3.5mm in different lengths

Experimental Animals
Twelve 12-month-old mongrel dogs, of either sex, weighing between 20 and 25 kg, were split up into three groups of four each. The dogs were thoroughly examined to find out their health status. The more emphasis was given to check any abnormality related to the musculoskeletal system and major debilitating diseases such as major organ failure (liver and kidneys).

Animal Management and Housing
The dogs were dewormed routinely for the internal parasite control using Febendazole 100mg/ml using a dose rate 1ml/2kg of body weight before 7 days of surgery. The dogs were vaccinated against Rabies using Rabisin injection 1ml/dog and Canine Distemper vaccine along with Leptospirosis, Canine Adenovirus and Canine Parvo virus which was repeated after 3 weeks. Throughout the study the dogs have been kept in indoor kennels under clean atmosphere, routinely monitored for light, air and moisture of the environment, given healthy clean dog feed and water.

Methods
Approach to the Olecranon
A skin incision was given lateral to the caudal midline of the leg. The incision was extended starting from distally third of the humerus to the proximal third of the Ulna and crossing the elbow joint between the Olecranon and lateral epicondyle. Subcutaneous fat and fascia were incised and undermined to facilitate skin retraction cranially beyond the lateral epicondyle and medially to the Olecranon. Another incision was made in the fascia of the triceps-brachii along the cranial border of the lateral head to allow elevation of the tendon from the Olecranon. The leg was flexed after elevation to give more exposure of the medial part. After the undermining of the fat present subcutaneously and fascia around the joint to the medial side till the caudal skin margins retracted back to the medial epicondyle. After cutting the triceps fascia, the cranial portion of the medial head of triceps undermined from the proximal part to the medial part of the condyle towards the Olecranon. The Ulnar nerve and collateral vessels lie parallel to the cranial part of the medial head and deep to it, under the antebrachial fascia. The nerve and vessel identified and protected throughout the procedure by retracting them distally. A small size saw was used to cut the Olecranon process from the caudal side with the constant force till the Olecranon pulled upward by the pulling forces of the triceps and can see the join clearly. If the anconeus muscle is intact, an incision is made through that muscle and underlying joint capsule near the attachments of from just proximally to the medial part of the Humeral condyle, extended distally to the Olecranon. Maximum visualization of the intraarticular part is gained by the complete flexion of the joint and retraction of the Anconeus muscle.

Preoperative checkup
Preoperative blood work Complete Blood Count, Liver Function Test, Renal Function Test, Serum calcium and Phosphorus were performed by withdrawing the 5ml venous blood.

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Pre-anesthesia and Anesthesia

The dogs were prepared for aseptic surgery after having the fast for about 10-12 hours before surgery. A thorough physical examination was done to check any abnormality. A thorough cardiac auscultation of the heart and lungs was carried out to get some useful information any pre-existing cardiopulmonary disease.

IV-catheterization done by accessing the Cephalic vein for the fluid administration and anesthesia induction. Xylazine HCL by the dose rate of 0.5mg/kg IM and Atropine-sulphate 0.02-0.04 mg/kg SQ injected as pre-anesthetic. After 10-15 minutes dog started getting slow down. The buprenorphine (BUPERON 0.3mg/ml by SAMI pharma) with the dose of 0.02-0.04 mg/kg IM, q4-12h injected as analgesic.

Ketamine-Xylazine with the dose rate of 5mg/kg and 0.5mg/kg respectively mixed together by 2:1 and injected 1ml/10kg slow IV for the induction and induction time was estimated 2-5 minutes.

Animal preparation for trial treatment

The dogs were prepared aseptically on lateral recumbancy. Hair clipper used to clip the excessive hair around the proposed site of incision 5cm each side. Pyodine surgical scrub used to scrub the area twice and then Povidone-Iodine solution and Methylated spirit used, respectively three times. Animals were draped using 5 drapes technique leaving the window for the incision.

Group A treatment-Tension Band wire

After exposing the Olecranon by above mentioned approach, a saw was used to create a transverse fracture until the fractured Olecranon pulled upwards by triceps muscles. Two K wires of 2mm pointed from both sides passed retrograde wise parallel to each other from fracture fragment and then inserted into Ulna distally. A hole is created through the manual drill machine 4cm below the fracture line and a cerclage wire of 2mm passed through it and then passed in fashion of eight from proximal pointed parts of K wires and tips of K wires bended distally and in the last cerclage wire tightened using a wire plier.

Group B treatment- Dynamic Compression Plate (DCP)

The fracture fragment was held in place by bone holding clamp along with the DCP 3.5mm 6 holes. A drill bit of 2.7mm was used to create the holes. The screws of 3.5mm were passed and tightened by screw driver of 3.5mm to achieve compression of the fracture fragment.

Group C treatment- Plaster of Paris (POP)

The dogs of group C underwent the conventional POP method of external repair. The Olecranon fracture was created by above mentioned approach and then incision line closed. A double layer of simple bandage was applied on the limb and the two orthopedic cotton pads were used to provide soft padding. Third layer of simple bandage of 4inches was used and in the last two layers of POP were applied over it.

Statistical Design

The mean values of each parameter recorded throughout the study period, were compared with the others in the same group. Mean values were also compared between the three groups. The normality of the data distribution for serum alkaline phosphatase, serum calcium and serum phosphorus values were assessed using Kolmogorov-Smirnov test. In each group hypothesis was carried out using analysis of variance on repeated measures. Statistical analysis between the groups was performed by using 95% confidence interval of the mean. The 5% level was considered significant. For bio statistical analysis and graphs, Excel 2010 and SPSS 20 were used.

Results

Lamneness

Group A

All four dogs in group A showed non weight bearing lameness in first week. In second week all dogs showed severe lameness and at the end of 4th week post operatively showed full weight bearing.

Group B

All four dogs exhibited non weight bearing lameness in first 7 days of post-operative days. Two dogs out of four, showed moderate lameness even after 14 days of post-operative period and other two showed severe lameness. At the end of 4th week period all dogs

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which showed slight lameness and at the end of 6th week full weight bearing.

Group C

All four dogs of group C behaved similarly for the first week after surgery as the dogs of group A and group B did. They have been observed for the whole observation period of 60 days for the lameness. They were 5th degree lamed throughout the observation period showing non weight bearing lameness. **Table 1. Lameness in the dogs of Group A, Group B and Group C every 15 days inertval**

Group A	Day15	Day 30	Day 45	Day 60
Dog 1	5	4	3	1
Dog 2	5	4	3	1
Dog 3	5	5	3	1
Dog 4	5	4	3	1
Group B				
Dog 1	5	4	4	2
Dog 2	5	5	4	2
Dog 3	5	5	3	2
Dog 4	5	5	3	2
Group C				
Dog 1	5	5	5	5
Dog 2	5	5	5	5
Dog 3	5	5	5	5
Dog 4	5	5	5	5

No lameness=1, Slight lameness =2, Moderate lameness =3, Severe lameness=4, Non-weight bearing =5. Statistically, the comparison between the group (A, B), group (A, C) and group (B, C) for the lameness postoperatively indicates that group A has more significance for the improvement of the lameness in the dogs treated by Tension band wire comparative to B and C and group B has more significance comparative to group C. P-value 0.00(<0.05).

Wound Healing

Group A

All of the dogs exhibited normal wound healing except one dog which had the implant failure due to the breakage of K wires and skin sutures so mild seroma formation and pain observed at the end of first week.

Group B

Dogs in group B behaved similarly in wound healing process as group A. No sinus formation or breakage of sutures presented throughout the observation period.

Group C

Dogs in group C which were treated by external method of fixation behaved similar to those group A and group B with respect to suture healing process.

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Table 2. Wound healing on weekly basis in dogs of Group A, Group B and Group C

GROUP A	Week 1	Week 2	Week 3	Week 4
Dog 1	1	0	0	0
Dog 2	1	2	2	1
Dog 3	1	0	0	0
Dog 4	1	0	0	0
GROUP B				
Dog 1	1	0	0	0
Dog 2	1	0	0	0
Dog 3	1	0	0	0
Dog 4	1	2	2	0
GROUP C				
Dog 1	2	1	0	0
Dog 2	2	1	0	0
Dog 3	2	1	0	0
Dog 4	2	1	0	0

Normal wound healing, 1= Mild pain and inflammation of operated site, 2= Severe pain and seroma formation

Serum Alkaline Phosphatase (ALP)

Serum Alkaline phosphatase levels have been documented on day 0,10,20,30 and monthly. The activity of serum ALP level in group A showed an increase in level in first 10 days and then gradually decreased to normal value once the callus has been formed showing the healing of the bone till the end of 60th day postoperatively.

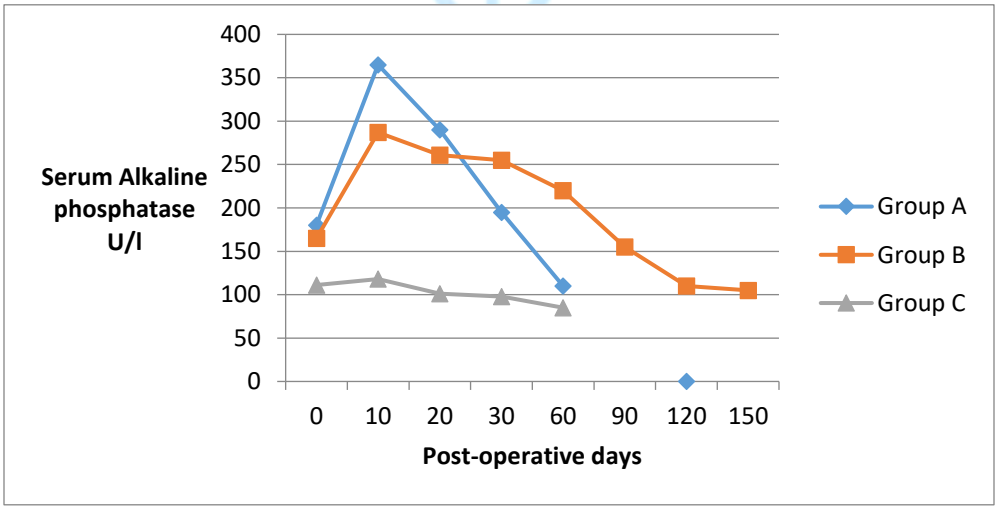


Figure 1. Graphical representation of ALP values postoperatively (Reference Interval 50-150U/L). Statistically, the difference between the Group A, Group B and Group C shows the significance with P-value of 0.000 ($p<0.05$). The change in the alkaline phosphatase values has significant value in the bone healing process.

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Serum Calcium Level (Ca)

In each group, the mean serum Ca concentration initially decreased and reached a minimum level on day 10 that was significant only in group B. Subsequently, the Ca concentration increase again and returned to initial values or higher.

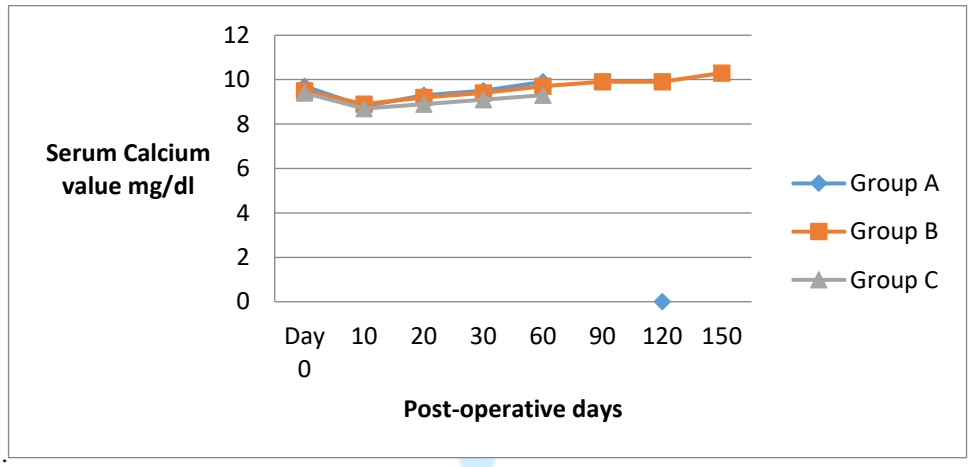


Figure 2. Graphical representation of serum Ca values postoperatively (Reference interval 9.3–11.9 mg/dL). Statistically, the difference between the Group A, Group B and Group C shows the significance with the P- value of 0.000 ($p<0.05$). The change in the serum Ca values has significant value in the bone healing process.

Serum Phosphorus Level (P)

Mean serum concentrations of P initially increased, reached a peak on day 10, and then decreased. The peak value was statistically significant when compared with that on day 0 only in group B; no other significant differences were found.

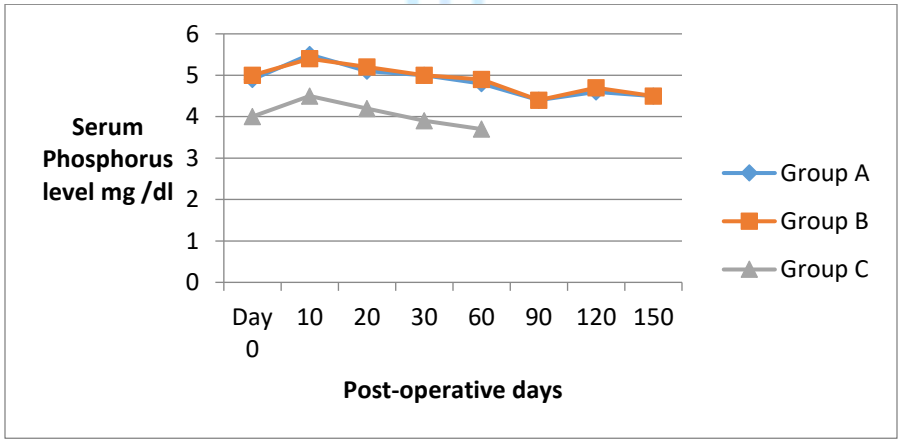


Figure 3. Graphical representation of serum Phosphorus level postoperatively (Reference interval 2.0–5.5 mg/dL). Statistically, the difference between the Group A, Group B and Group C shows the significance with the P- value of 0.000 ($p<0.05$). The change in the serum P values has significant value in the bone healing process.

Discussion

The number of orthopedic patients brought to the hospital is increasing day by day. The number of small animal orthopedic patients especially companion animals is more than large animals and it needs utmost surgical attention on emergency basis. Sometimes the wild animals like deer also presented with the orthopedic ailments. Being a pet, people are more concern sentimentally than economically. Sometimes such bones of the animal are involved

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ISSN: (e) 3007-1607 (p) 3007-1593

which don't lend themselves to primitive methods of limb splintage principle and one has to resort to the method of internal fixation.

Avulsion fractures of the bony prominences are not uncommon in small as well as large animals. In such cases special methods of treatment have to be used which would convert the distracting forces into compressive forces. For that purpose various techniques like tension band wire, compression screws and compression plates have been used with varying degree of success rates .The present study comprised of comparison of three basic principles of tension band wire, dynamic compression plate and conventional POP for the repair of surgically avulsed olecranon fracture in the dog. The experiment also provided an opportunity to evaluate the comparative efficacy of tension band wire, DCP and POP.In the present study healing/dehiscence of cutaneous suture line was observed in certain cases which is not an uncommon finding and has also been reported previously. Proper asepsis is mandatory off course in surgical manipulation, even then the possibility of infection in post-operative period cannot be ruled out. This may be the possible cause of breakage of suture line in these animals. In present study the breakage of suture line and delayed wound healing is higher in case of DCP and POP than tension band wire. In this experiment the breakage of screws of DCP noticed which ultimately led to the failure of the implant under the pulling forces of triceps muscles. The possible reason of the loosening of screws would be the constant pulling forces of distracting forces of triceps muscles. Some over drilling of the avulsed olecranon fragment made it weak also for the support of screws. The radiographic findings of these cases also supported the clinical picture. There was minimal callus formation in some cases of DCP and none at all in other too. This clearly indicated that the compression plate was not the very effective method to be used on avulsed olecranon fracture at least. The possible reason being that the olecranon fracture fragment too small to be over drilled which caused the weakness of the fracture fragment to accommodate the screws (Khan MA, 1989).

On the other hand tension band wire gave better results and effectively counteracted the contracting forces of triceps. All the cases treated with this method showed better clinical and radiographic pictures. The lameness seen during the first post-operative week disappeared gradually till the end of the experiment period. The olecranon effectively compressed by this method. Radiographic findings showed complete union of fracture line except dog no 4 of Group A in which fracture line was slightly evident. Similar findings were also notices in the experiments done in the past (Wang W, 2012)

The analysis of the results clearly indicates that the tension band wire is a better choice for fixing the avulsed olecranon fracture in dog. As a matter of fact this procedure must be preferred over the compression plate and POP where distracting forces leads to the implant failure and unable to counteract the distracting forces of triceps muscles. The reports of their successful use in humans cannot be compared with the animals. The human patient mostly has the bed rest till the recovery and animals are mostly ambulatory during first post-operative week. This definitely put some stress on the implant and results in the failure of mechanically less strong procedure such as compression plate and POP as experienced in present study. The other point which favors the use of tension band wire is that it is more economical than DCP and less damaging to the nearby tissues.

In mature animals under the given ideal conditions, the expected time for the bone union of uncomplicated cases is approximately 5-8 weeks (Newton CD, 1998, Weisbrode SE, 1995). Delayed union takes as long as twice the time period of normal union for specific cases (Braden TD, 1976). Delayed union is responsible for the extra amount of callus formation and prolonged the healing process (Aron DN, 1998). Some conditions such as less vascularity and severe soft tissue injury contribute to nonunion (Betts CW, 1995).Normal fracture healing is the process generated by osteoblastic activity. Osteoblasts are responsible for the new bone formation and mineralization (Johnson KA, 2000, Bolger JT, 1975). They secrete a large amount of alkaline phosphatase, which is involved in this process (Allen MJ, 1998). Hydroxyapatite crystals deposited in bone matrix are usually composed of calcium and phosphorus (Meller Y, 1984).ALP is believed to either increase the concentration of local, inorganic P or neutralize inorganic pyrophosphate,

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ISSN: (e) 3007-1607 (p) 3007-1593

an inhibitor of hydroxyapatite crystal formation (Rosol TJ, 1997, Feldman BF 1977, Volpin G, 1986). The two main events following the fracture are an acute reaction, characterized by significantly increased serum alkaline phosphatase, hypocalcemia and hyperphosphatemia and an anabolic hormone responsible for changes in calcium metabolism. At the cessation of callus formation serum alkaline phosphatase, calcium and phosphorus levels return to normal (Bolger JT, 1975). Similar ALP changes were evident in group A and group B where callus formation is achieved and ALP value increased in first week and higher on day 10. However in the study by Meller et al, the increase was significant in 24 hours of fracture similar to that evident in humans (Nilsson BE, 1972, Sferopoulos NK,1997).

Serum calcium and phosphorus changes recorded in this study were also reported by some researches previously (Nilsson BE, 1972). First 10 days after the repair of avulsion fracture showed the decrease in the normal level of serum calcium and increase the level of serum phosphorus. In this study the changes in the ALP activity paralleled the process of fracture healing by physical and radiological evidences in group A where the callus formation ceased at 60 days of fracture repair by tension band wiring. In group B the serum ALP activity was still high on 60 days where the fracture was repaired by Dynamic compression plate, showing the delayed union comparative to group A. There were no significant changes in the serum ALP activity in group C, showing no callus picture. So the significance of serum alkaline phosphatase is high in relation to the bone healing and callus formation. It raised the question that the nonunion required the surgical management as compared to bone union and delayed union (Kaderly RE, 1993, Boudrieau RJ, 2000).

Serum ALP activity correlated well with the process of bone healing, the bone isoenzyme of ALP (BALP) is considered a specific bone marker of bone formation. The inclusion criteria for the production of ALP by liver and corticosteroid induced was already eliminated in this study (Allen MJ, 1998).

Conclusion

In conclusion, for canine olecranon avulsion fracture comparative efficacy of tension band wiring is better than the dynamic compression plate. Physical and radiological evidences revealed that callus formation was early in the dogs comparative to those repaired by dynamic compression plate and there was no callus formation the group C dogs where the treatment method was Plaster of Paris. Secondly, the serum ALP activity during the healing process in combination with physical and radiologic examination can be additional useful tool in the prediction of the fracture at risk of developing nonunion and aiding the clinician to adapt accordingly.

Suggestion

Concluding the above experiment, the dog having the olecranon avulsion fracture can be better repaired by the tension band wire principle as compared to the dynamic compression plate method or POP and serum alkaline phosphatase along with the serum calcium and phosphorus levels can be a good indicator of the bone healing.

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